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(71) Applicant
Sulzer Brothers Limited
(Switzerland)
Winterthur
Switzerland
(72) Inventor
Eduard Blaha
(74) Agent and/or Address for Service
Kilburn and Strode
30 John Street
London WC1N 2DD

(54) Method of and apparatus of individually cooling a plurality of rooms

(57) In a room cooling system operating with a variable quantity of cooling air, the primary air is cooled to at least 10°C below the room air temperature of the room (15) to be cooled. This cool primary air is mixed in an induction system (1) with secondary air drawn in from the room (15) before the mixed air is ejected as cooled air into the room (15).

Mixing the primary air and the room air before discharge into the room (15) enables primary air temperatures to be lower; consequently, smaller volumes of primary air are required for a given removal of heat than previously, so that the air-conditioning plant can be smaller – i.e., the space taken up thereby and its capital cost and power consumption can be reduced.

Also, drawing in room air in an induction system (1) ensures that the mixture ratio between primary air and secondary air remains substantially constant for the different quantities of primary air required to produce different amounts of cooling.

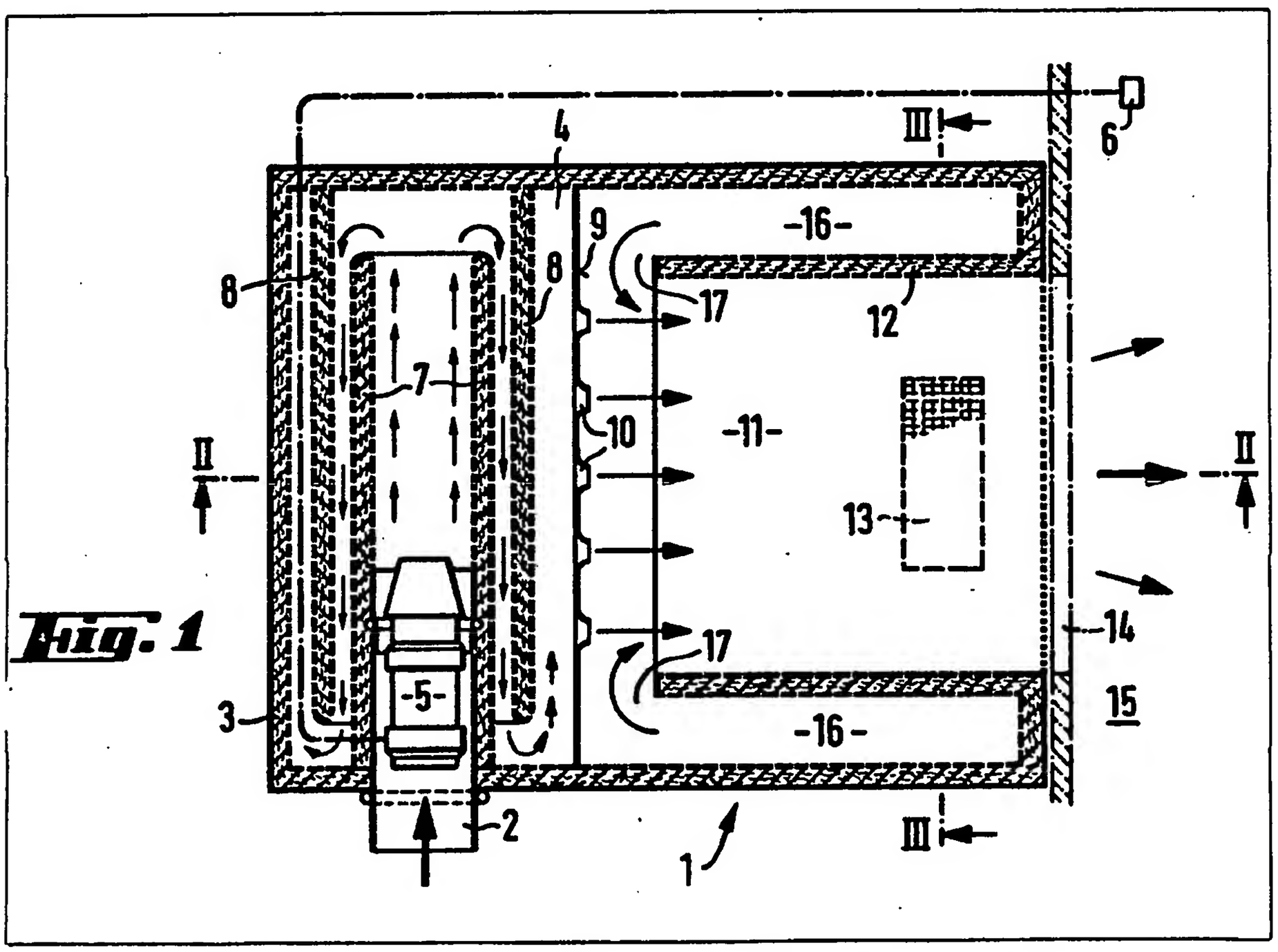

Fig. 1

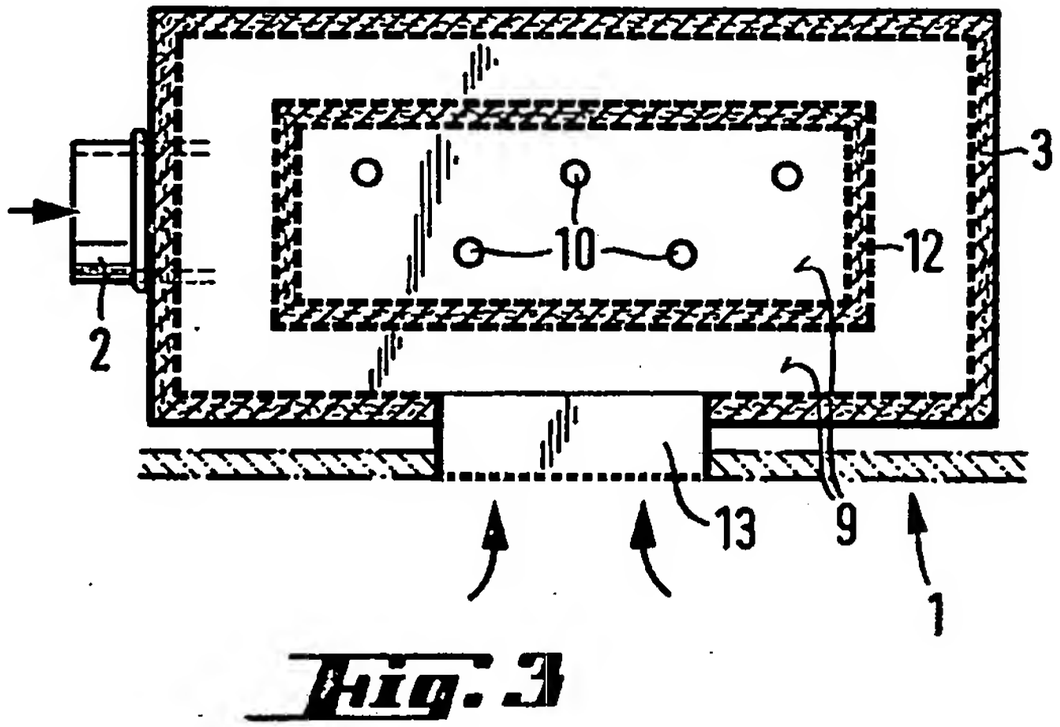

Fig. 3

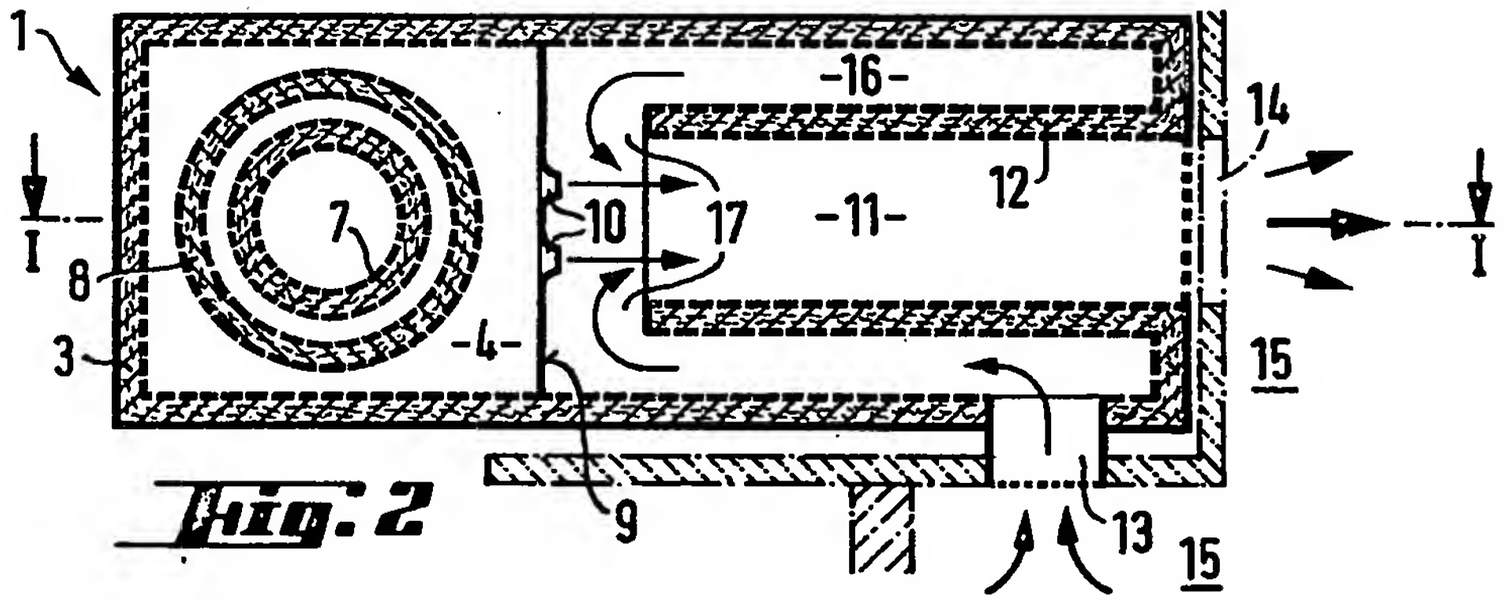

Fig. 2

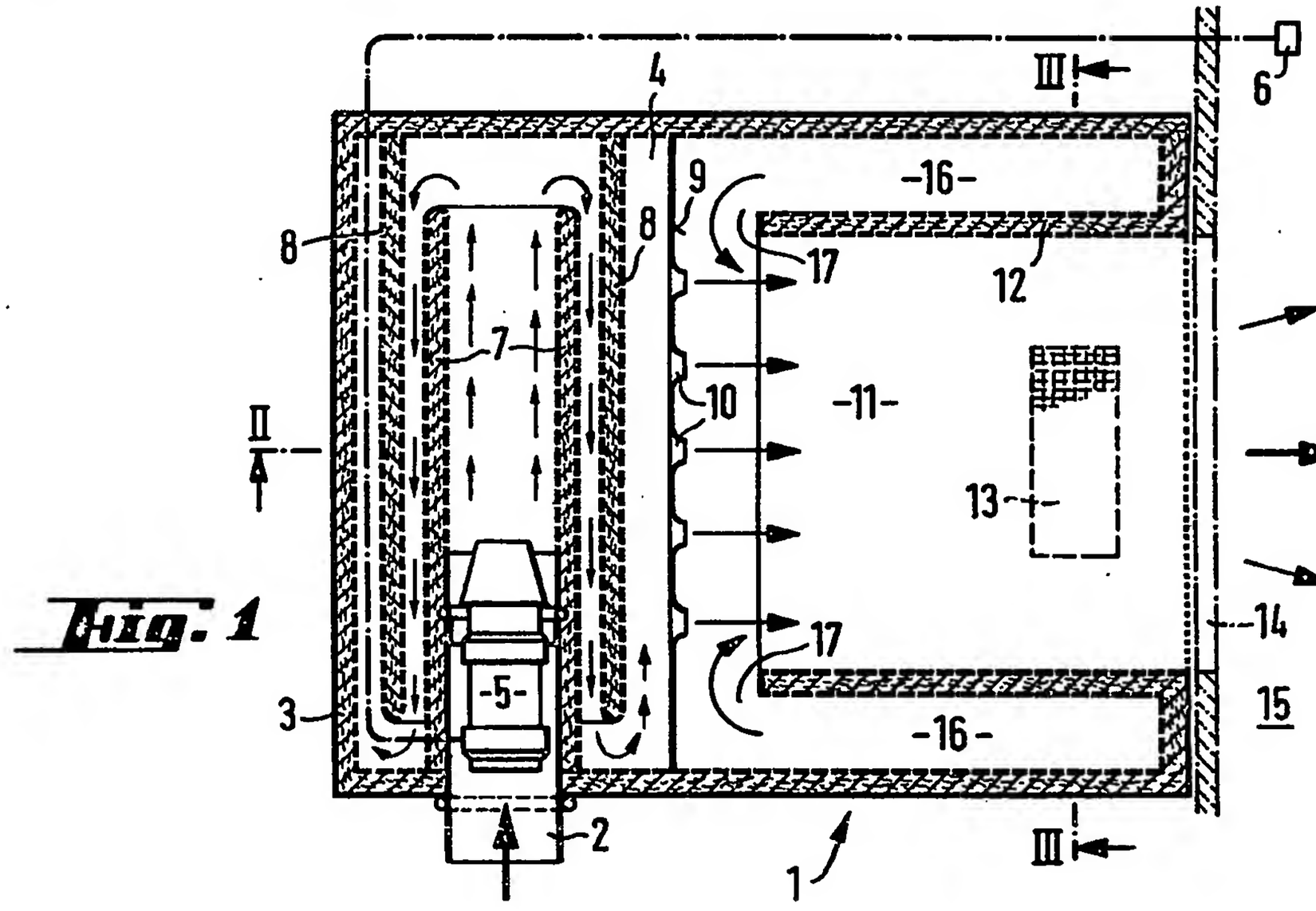

Fig. 1

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SPECIFICATION

Method of and apparatus of individually cooling a plurality of rooms

This invention relates to a method of individually cooling a plurality of rooms by means of a central ventilating system which supplies from an air-conditioning plant to the various rooms air needed for renewal and humidification in the form of cooling air at a constant temperature considerably below room temperature, the quantity of injected cool air in excess of the minimum requirement being controlled by means of a room thermostat to control cooling. The invention also relates to apparatus for such cooling.

The method outlined is known, for instance, from Swiss patent specification 555 519 wherein the cold input is adapted by rate of flow control of the prepared and cooled primary air delivered by the air-conditioning plant. The cool primary air is directly injected into the room, preferably near the ceiling, where it mixes – i.e., only after it has issued into the room – with the room air because of the induction effect of its flow.

Practical experience with these known methods and apparatus for cooling have shown that, to ensure the comfort of the room occupants, the constant temperature of the injected primary air must be not more than from 8 to 10°C below the room temperature of approximately 26 to 28°C, otherwise the quantity of primary air, more particularly on a low cooling load, becomes so small that it has little induction effect, fails to mix adequately with the room air, "drops" into the room and forms cold islands near the floor.

Consequently, relative large quantities of primary air must be available for maximum cooling performance, so that the air-conditioning plant producing the primary air is correspondingly very expensive and takes up considerable space.

It is an object of the invention so to modify the known cooling method on the basis of variable primary air quantities that captial costs and energy costs associated with maximum cooling output are reduced. Also, apparatus to carry out the modified method should comply with the additional requirement that the ratio of primary air to induced secondary or room air remains at least substantially constant over the whole range of primary air flows injected into the room.

According to one aspect, the present invention provides a method of individually cooling a plurality of rooms by means of a central ventilating system which supplies from an air-conditioning plant to the several rooms air needed for renewal and humidification in the form of cooling air at a constant temperature below room temperature, the quantity of injected cool air being controlled by means of a room thermostat to control cooling, the cool primary air supplied to the room by the air-conditioning means being cooled to at least 10°C below room temperature and, before issuing into the room as cooling air, being mixed with room air drawn in as secondary air.

Since, in the method according to the invention, the primary air can for a given primary air temperature – i.e., the same temperature of the air reaching the room – be cooled more than previously – advantageously to form 12 to 18°C below room temperature – the quantities of primary air required can be reduced substantially; consequently, all parts of the air-conditioning apparatus can be smaller and more compact and the power consumption needed for primary air conveyance can be reduced considerably. Advantageously – but not necessarily – the room air mixed with the cool primary air is taken from the room it is required to cool.

To maintain comfortable conditions in the region where the room occupants are, it has been found advantageous if the cool primary air and the room air are mixed together in a proportion of from 4:1 to 1:1; the optimum mixing proportion economically can be more particularly 3:2.

According to a second aspect of the present invention, apparatus for the individual cooling of a plurality of rooms comprises an air conditioning plant and a central ventilating system for supplying to the several rooms air needed for renewal and humidification in the form of cooling air at a constant temperature below room temperature, a cool air feed line leading to an air induction means for each room, and a room thermostat in each room connected to control the rate of flow of cooling air to the respective room, each air induction means including a pressure chamber from which discharge nozzles lead into an outlet chamber which is surrounded by a secondary air induction chamber having at least one inlet opening for room air.

Of course, apparatus constructed according to the invention must, just like the conventional apparatus, satisfy general requirements for silent operation and for the virtual absence of condensation on the cold parts of the apparatus. In this connection, very compact arrangements can be provided if the pressure chamber comprises a sound damper formed by sound-damping tubes of different diameters which telescope one within another and if at least part of the walls of the air induction means are sound-absorbing and/or heat-insulating.

As previously stated, one of the objects of the invention is to ensure that the proportions of primary air and induced secondary or room air remain at least substantially constant over the whole range of primary air flow rates. This is achieved because, while the room air is

being mixed inside the induction system, the resistance to the induction of room air remains at all primary air rates of flow substantially in a fixed relationship to the exit speed of the primary air from the nozzle-like discharge orifices. Consequently, if the shaping of the discharge nozzles and/or the devising of the resistance for the flow of induced room or secondary air is given consideration in the design of the induction system, virtually a predetermined relationship between primary air and secondary air in the flow of air entering the room can be achieved; more particularly, the relationship can be such that the proportion of primary air is 60% and the proportion of secondary air is 40%.

Another considerable advantage of the invention is that it is possible to obtain a relatively low pressure loss in the induction system.

The invention may be carried into practice in various ways but one form of air-conditioning apparatus embodying the invention and its method of operation will now be described by way of example with reference to the accompanying diagrammatic drawings, in which:

Figure 1 is a view in plan, on the line I–I of Fig. 2, of an induction system forming part of the apparatus;

Figure 2 is a section on the line II–II of Fig. 1; and

Figure 3 is a section on the line III–III of Fig. 2.

Referring to Fig. 1, and induction system 1 is supplied through a line 2 with primary air prepared and cooled in an air-conditioning plant (not shown). The primary air line 2 extends into a casing 3 of the system 1 and terminates in a pressure chamber 4, the free end of the line 2 extending into the chamber 4 and comprising a discharge controller 5 of known construction. The discharge controller is used in known manner to control the flow of primary air in dependence upon room temperature as detected by a room thermostat 6.

Disposed in the chamber 4 for sound damping are two telescopically engaging sound-damping tubes 7, 8 of different diameter from one another; the primary air in passing through the chamber 4 is compelled to zigzag through the tubes, so that satisfactory sound damping is provided despite the relative shortness of the tubes 7, 8.

Perpendicularly to the primary air inflow direction, the chamber 4 is bounded by a partition 9 formed with nozzle-like discharge orifices 10 so disposed that the streams of primary air discharging from them are directed towards an outlet chamber 11 formed by a hollow parallelpiped-shaped member 12. The chamber 11 terminates in an outlet orifice 14 which has a grid or lattice and through which the primary air is ejected into the room 15.

Extending around the member 12 is an induction chamber 16 which is bounded by the casing 3 and through which flows room air drawn in as secondary air by the "streams" of primary air, the room air being drawn along by these "streams" by way of a venturi-like annular gap 17 between the wall of member 12 and the partition 9. Room air enters the chamber 16 from the room 15 through a griddled intake opening 13 in the casing 3.

Advantageously, the induction system 1 is so arranged in the ceiling zone of the room 15 to be cooled that, as indicated in Fig. 2, the inflowing mixed air issuing from the opening 14 issues into the room 15 substantially horizontally and parallel to the ceiling, the intake opening 13 being in the bottom wall of the casing 3 – i.e., the room air being taken in upwardly.

To obviate the formation of condensation and to provide sound damping in addition to that provided by the sound damper 7, 8, the casing 3 and the member 12 are made of a material, such as glass wool or mineral wool, which is a sound and heat insulant. It may, however, be possible for only part of these components to be made of such a material.

In conclusion, an example will be given to show the effectiveness of the apparatus and its method of operation.

It will be assumed that the maximum quantity of heat to be removed to maintain a constant temperature of 26°C in the room to be cooled is 700 W. To remove this amount of heat a primary air flow of 160 m^3/h at a temperature of approximately 12.5°C enters the induction system 1. 110 m^3/h of room air, as secondary air, is induced into the primary air flow in the system 1 by means of the primary air flow discharging from the chamber 4 through nozzles 10 at a speed of 11 m/sec. Consequently, the air issuing into the room through the grid 14 in maximum conditions of operations is 270 m^3/h and is at a temperature of approximately 18°C. For minimum cooling the quantity of primary air at constant temperatures is 80 m^3/h; this reduced primary air flow drawing in 55 m^3/h of room air as secondary air, so that the inflow of air is 135 m^3/h.

The component of primary air in the mixed or inflow air is therefore constant at around just about 60%, as compared with a little over 40% for the room air.

CLAIMS

1. A method of individually cooling a plurality of rooms by means of a central ventilating system which supplies from an air-conditioning plant to the several rooms air needed for renewal and humidification in the form of cooling air at a constant temperature below room temperature, the quantity of injected cool air being controlled by means of a room thermostat to control cooling, the cool primary

air supplied to the room by the air-conditioning means being cooled to at least 10°C below room temperature and, before issuing into the room as cooling air, being mixed with room air drawn in as secondary air.

2. A method as claimed in Claim 1 in which the cool primary air is cooled to form 12 to 18°C below room temperature.

3. A method as claimed in Claim 1 or Claim 2 in which the cool primary air and the room air are mixed together in a proportion of from 4:1 to 1:1.

4. A method as claimed in Claim 1 or Claim 2 in which the cool primary air and the room air are mixed together in a proportion of 3:2.

5. A method as claimed in any of the preceding claims in which the room air is drawn in directly from the room to which it is delivered after mixing with cool air.

6. Apparatus for the individual cooling of a plurality of rooms comprising an air conditioning plant and a central ventilating system for supplying to the several rooms air needed for renewal and humidification in the form of cooling air at a constant temperature below room temperature, a cool air feed line leading to an air induction means for each room, and a room thermostat in each room connected to control the rate of flow of cooling air the respective room, each air inductive means including a pressure chamber from which discharge nozzles lead into an outlet chamber which is surrounded by a secondary air induction chamber having at least one inlet opening for room air.

7. Apparatus as claimed in Claim 6 in which the pressure chamber comprises a sound damper formed by sound-damping tubes of different diameters which telescope one within another.

8. Apparatus as claimed in Claim 6 or Claim 7 in which at least part of the walls of the air induction means are sound-absorbing and/or heat-insulating.

9. Apparatus as claimed in Claim 6 or Claim 7 or Claim 8 in which the shape and dimensions of the air passages into, through and out of the air induction means are such that in use of the mixed-air stream issuing from the outlet chamber contains substantially 60% cool primary air and 40% intaken secondary air.

10. A method of individually cooling a plurality of rooms substantially as described herein with reference to the accompanying drawings.

11. Apparatus for the individual cooling of a plurality of rooms substantially as described herein with reference to the accompanying drawings.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU03/00347

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. [7]: F24F 1/01, 13/26

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B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC (7): F24F 1/01, 13/06, 13/26

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2371357 A (HALTON OY), 24 July 2002 Whole document	1-20
X	WO 02/42691 A (HALTON OY), 30 May 2002 Whole document	1-20
X	US 4711162 (ERIKSSON), 8 December 1987 Whole document	1-20

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

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17 April 2003	30 APR 2003
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer ADRIAN GILLMORE Telephone No : (02) 6283 2125

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU03/00347

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4535685 (REUTER), 20 August 1985 Whole document	1-20
X	US 4448111 (DOHERTY), 15 May 1984 Whole document	1-20
X	GB 2109107 A (SULZER BROTHERS LTD.), 25 May 1983 Whole document	1-20

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU03/00347

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
GB	2371357	DE	10157408	FI	20002589	FR	2817329
		NO	20015721	SE	200103792	US	2002062948
WO	200242691	AU	200223711	FI	20002591	FR	2817331
US	4711162	AU	49670/85	CA	1263052	DK	3069/86
		EP	199762	FI	862686	NO	844320
		WO	8602710				
US	4535685	AU	29120/84				
US	4448111	NONE					
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